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Calculation of Comparison of Efficiency of Main Driving Machine Sister Ship

Henny Pasandang Nari
Politeknik Ilmu Pelayaran Makassar, Indonesia
*e-mail: hennypnari@gmail.com

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Calculation, Comparison, Efficiency, Sister Ship

ABSTRACT
The purpose of this study is to calculate the efficiency ratio of the main propulsion engine of the sister ship. Based on the research focus that has been described in the problem formulation, the type of research used is a type of quantitative research using comparative descriptive methods. This study took data on 2 (two) PELNI passenger ships docked at Makassar port, namely KM Bukit Siguntang and KM Lambelu. The process of data collection, data processing and analyzing research data lasted for 4 (four) months from June to September 2022. From the results of data processing contained in the results of research and discussion, it can be concluded that KM Lambelu engine efficiency of 44.145% where specific fuel consumption is 0.1848. KM Bukit Siguntang engine efficiency of 44.07% where specific fuel consumption is 0.1851.

INTRODUCTION

Engine efficiency refers to the engine's ability to convert available energy from fuel into useful motive power (Conlon et al., 2015). When not running, engine efficiency is zero because the engine does not drive the vehicle and only operates accessories, such as water pumps and generators. Compared to gasoline engines, diesel engines are considered more efficient(Fraser, Blaxill, Lumsden, & Bassett, 2009). Diesel engines use high compression on the cylinders to ignite fuel. Compared to gasoline engines, diesel engines are considered more efficient. Diesel engines use high compression on the cylinders to ignite fuel. The compression ratio of the engine will also affect the efficiency of the engine(Gnanamoorthi & Devaradjane, 2015). This is due, in part, to the engine's ability to convert heat from the combustion process to produce energy. The higher the compression ratio, the better the overall efficiency of the machine(Satyanarayana, Padala, Rao, & Umamaheswararao, 2015). The amount of oxygen an engine is able to absorb affects its ability to operate more efficiently(Hedge, Weber, Gingrich, Alger, & Khalek, 2011). Diesel engines have the best thermal efficiency compared to internal combustion and other external combustion engines, because they have a very high compression ratio (Wang et al., 2020). Low-speed diesel engines (ship engines) can have thermal efficiency of more than 50% (Alfendry, Budiarto, & Kiryanto, 2018).

A diesel engine is a unit of equipment that is generally used as a means of driving or generation(Hansen & Wendt, 2015). In the shipping industry, especially merchant ships, diesel engines are still most often used as the main mover of ships with various brands of diesel engines used(Čampara, Hasanspahić, & Vujičić, 2018). In the daily operation of diesel engines as the main engine of the ship, there are many possibilities for problems or incompatibilities in the ship engine, so that it can interfere with the performance of the engine itself(Noor, Noor, & Mamat, 2018). These problems or incompatibilities can be caused by internal or external factors of the diesel engine itself, such as damage that occurs to engine components or systems that support the performance of the engine itself (Kalghatgi, 2014).

Many problems occur in ship engines, but because of the difficulty and lack of information about solving these problems, it can allow the process of solving problems and maintaining ship engines will be slow(Landset, Khoshgoftaar, Richter, & Hasanin, 2015). Therefore, to solve problems that occur in ship engines, a lot of information is needed that can help solve the problem (Hartaya & Suhartini, 2021). For example, in cases that

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often occur on ships of PT. PELNI or PT. Dharma Lautan Utama, there are often damage or problems with the main engine caused by various causes, but due to lack of information about the cause of the problem (Priambudi, 2021). Therefore, researchers will conduct a study entitled Comparative Calculation of the Efficiency of Sister Ship's Main Propulsion Engine(Baldi, Johnson, Gabrielii, & Andersson, 2015). The purpose of this study is to calculate the efficiency ratio of the main propulsion engine of the sister ship.

METHODS

Based on the research focus that has been described in the problem formulation, the type of research used is a type of quantitative research using comparative descriptive methods. This study took data on 2 (two) PELNI passenger ships docked at Makassar port, namely KM Bukit Siguntang and KM Lambelu. The process of data collection, data processing and analyzing research data lasted for 4 (four) months from June to September 2022. Research data collection was carried out by collecting ship manual book data, namely data on the main engine.

RESULTS

Research Results

1. The results of the research obtained are KM Siguntang and KM Lambelu using the same type of fuel, namely Marine Diesel Oil (MDO) Bio Solar.

Table 1 Main Motor Specification Data

No	Main Motor Specifications	
	KM Siguntang Hill	KM LAMBELU
1	Krup Mak Type : 6M 601C	Krup Mak Type : 6M 601C
2	Output MCR : 6400 kW x 2 bh	Output MCR : 6400 kW x 2 bh
3	Rpm 428 – MEP : 18,9 bar	Rpm 428 – MEP : 18,9 bar
4	Serial No : Left 63209 Right 63208 Year 1996	Serial No : Left 63209 Right 63208 Year 1996
5	P Propeller CPP Lips B.V Type : 4C 11	Propeller CPP Lips B.V Type : 4C 11
6	Dia 4100 mm, material: Bronze	Dia 4100 mm, material: Bronze

Source: Manual Book KM Bukit Siguntang, KM Lambelu

Table 2 Main Size Data of Ships

No	Main Size	KM Siguntang Hill	KM Lambelu
1	Entire length	46,50 m	46,50 m
2	Length between vertical lines (LBP)	130,00 m	130,00 m
3	Width (B)	23,40 m	23,40 m
4	Loaded summer	5,90 m	5,90 m
5	Height up to deck 4	10,80 m	10,80 m
6	Height up to deck 5	13,40 m	13,40 m
7	Height up to deck 7 (lifeboat)	18,60 m	18,60 m
8	Height up to deck 8 (platform)	21,20 m	21,20 m
9	High to the top of the pole	41,50 m	41,50 m
10	DWT	3686 TDW	3685 TDW
11	Displacement	10578 T	10583 T
12	GRT	14701 RT	14649 RT
13	NRT	5360 RT	4395 RT
14	Cruising Range	5500 thousand	5600 thousand
15	Operational Speed	20,3 knot	20,3 knot

Source: Manual Book KM Bukit Siguntang, KM Lambelu

The following KM Lambelu ship data at *full load is* used as calculation data:

Engine output power (PM)	: 6400 kW
Engine speed (n)	: 428 rpm
Engine speed	: 20.3 knots
Average effective pressure (MEP)	: 18.9 bar
Environment temperature	: 24 ^{0}C
Exhaust gas temperature	: 370 ^{0}C

Charge air cooler
Inlet air temperature : 169 ^{0}C
Outgoing air temperature : 47 ^{0}C
Number of Cylinders (i): 6 cylinders
Stroke (step) (z) : 4
Calorific value of diesel fuel (HV) : 42276 $\frac{kJ}{kg}$

The following is the data of the KM Bukit Siguntang ship at *full load which* is used as calculation data:
Engine output power (PM) : 6400 kW
Engine speed (n) : 428 rpm
Engine speed : 20.3 knots
Average effective pressure (MEP) : 18.9 bar
Environment temperature : 24 ^{0}C
Exhaust gas temperature : 380 ^{0}C
Charge air cooler
Inlet air temperature : 168 ^{0}C
Outgoing air temperature : 47 ^{0}C
Number of Cylinders (i) : 6 cylinders
Stroke (step) (z) : 4
Calorific value of diesel fuel (HV) : 42276 $\frac{kJ}{kg}$

Machine Efficiency Calculation

1. KM Lambelu

1. Minimum air requirement (m_{LMIN})

m_{LMIN} = 0.377 HP.10 - 1.737 $^{-3}$
= 0,377. 42.276 . 10 - 1,737 $^{-3}$
= 14,2 $\frac{kgu}{kgbb}$

2. Specific fuel consumption (m_{BSPEC})

m_{BSPEC} (169 x 1.019628 + 42276) + m_{BSPEC} x 2.5 x 14.2 x 47 x 1.00702 = 1 + m_{BSPEC} (1 + 2.5 x 14.2) x 370 x 1.6320 + $\frac{0,5/6400}{6400}$

m_{BSPEC} = 0,1848 $\frac{kg}{kWh}$

3. Fuel consumption per hour (m_B)

m_B = m_{BSPEC} x P_M
= 0,1848 x 6400
= 1183 () $\frac{kg}{h}$

4. Actual air requirement (m_L)

m_L = m_B x n x m_{LMIN}
= 1183 x 2,5 x 14,2
= 41996,5 $\frac{kgu}{kgbb}$

5. Engine efficiency () η

$$\eta = \frac{1}{0{,}1848} \frac{3600}{(169x1{,}019628 + 42276 + 2{,}5x14{,}2x47x1{,}00702)}$$

$$= \frac{1}{0{,}1848} \frac{3600}{44128}$$

= 0,44145 = 44,145%

2. KM Siguntang Hill

1. Minimum air requirement (m_{LMIN})

m_{LMIN} = 0.377 HP.10 - 1.737 $^{-3}$

= 0,377 . 42.276 . 10 - 1,737 $^{-3}$

= 14,2 $\frac{kgu}{kgbb}$

2. Specific fuel consumption (m_{BSPEC})

m_{BSPEC} (168 x 1.019494 + 42276) + m_{BSPEC} x 2.5 x 14.2 x 47 x 1.00702 = 1 + m_{BSPEC} (1 + 2.5 x 14.2) x 380 x 1.6335 + $\frac{0{,}5/6400}{6400}$

m_{BSPEC} = 0,1851 $\frac{kg}{kWh}$

3. Fuel consumption per hour (m_B)

m_B = m_{BSPEC} x P_M

= 0,1851 x 6400

= 1185 () $\frac{kg}{h}$

4. Actual air requirement (m_L)

m_L = m_B x n x m_{LMIN}

= 1185 x 2,5 x 14,2

= 42067,5 $\frac{kgu}{kgbb}$

5. Engine efficiency ()η

$$\eta = \frac{1}{0{,}1851} \frac{3600}{(168x1{,}019494 + 42276 + 2{,}5x14{,}2x47x1{,}00702)}$$

$$= \frac{1}{0{,}1851} \frac{3600}{44127}$$

= 0,4407 = 44,07 %

Table 3 Machine Efficiency Calculation Results

No	Information	KM Lambelu	KM Siguntang Hill
1.	Minimum air requirement (m_{LMIN})	14,2 $\frac{kgu}{kgbb}$	14,2 $\frac{kgu}{kgbb}$
2.	Actual air requirement (m_L)	41996,5 $\frac{kgu}{kgbb}$	42067,5 $\frac{kgu}{kgbb}$

3.	Specific fuel consumption (m_{BSPEC})	0,1848 $\frac{kg}{kWh}$	0,1851 $\frac{kg}{kWh}$
4.	Fuel consumption per hour (m_B)	1183 $\frac{kg}{h}$	1185 $\frac{kg}{h}$
5.	Engine efficiency ()η	44,145 %	44,07 %

Discussion

The following will be described the results of the calculation of the comparison of the efficiency of the main propulsion engine of sister ships where the engine efficiency obtained for KM Lambelu is 44.145% while the engine efficiency for KM Bukit Siguntang is 44.07%. The efficiency of the KM Lambelu engine is slightly greater than the efficiency of the KM Bukit Siguntang engine. Engine efficiency has an inverse relationship with specific fuel consumption (m BSPEC) where the higher the efficiency the more efficient the fuel consumption, this can be seen in the specific fuel consumption (m BSPEC) KM Lambelu of 0.1848 and the specific fuel consumption (m $\frac{kg}{kWh}$ BSPEC) KM Bukit Siguntang of 0.1851 $\frac{kg}{kWh}$. Basically, the engine efficiency obtained on both ships is the same, this is because some data such as data on the specifications of the main motor and the specifications of the main size are the same, which distinguishes only in fuel consumption every hour even though the difference is actually very small. The influencing factors are also the maintenance schedule of the two ships is the same, namely carrying out routine maintenance overhauls once every year, and the age of the ship is the same where the year of shipbuilding is in 1996.

CONCLUSION

From the results of data processing contained in the results of research and discussion, it can be concluded that KM Lambelu engine efficiency of 44.145% where specific fuel consumption is 0.1848. KM Bukit Siguntang engine efficiency of 44.07% where specific fuel consumption is 0.1851.

Further research needs to be done related to the calculation of engine efficiency using a more detailed formula using ship operational data.

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